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(54) **OPTICAL ELEMENT FILTERING ULTRAVIOLET LIGHT AND LENS MODULE INCLUDING SAME**

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G02B 1/115 (2015.01)
G02B 5/28 (2006.01)

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CPC ***G02B 5/208*** (2013.01); ***G02B 1/115*** (2013.01); ***G02B 5/283*** (2013.01)

(58) **Field of Classification Search**
CPC G02B 5/28–5/289; G02B 1/10–1/18
USPC 359/350, 577–590, 351–358, 359–361
See application file for complete search history.

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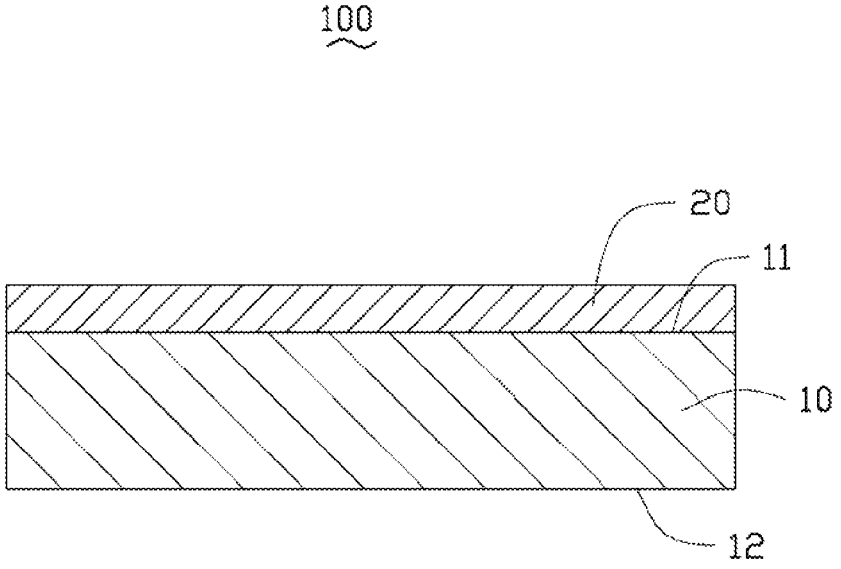
(57) **ABSTRACT**

An optical element includes a substrate and a film. The substrate made of sapphire. The film is covered on the substrate and is configured for increasing reflectivity of ultraviolet lights and filtering the ultraviolet lights. The film includes a plurality of high refractive index layers and a plurality of low refractive index layers alternately stacked on the substrate.

4 Claims, 3 Drawing Sheets



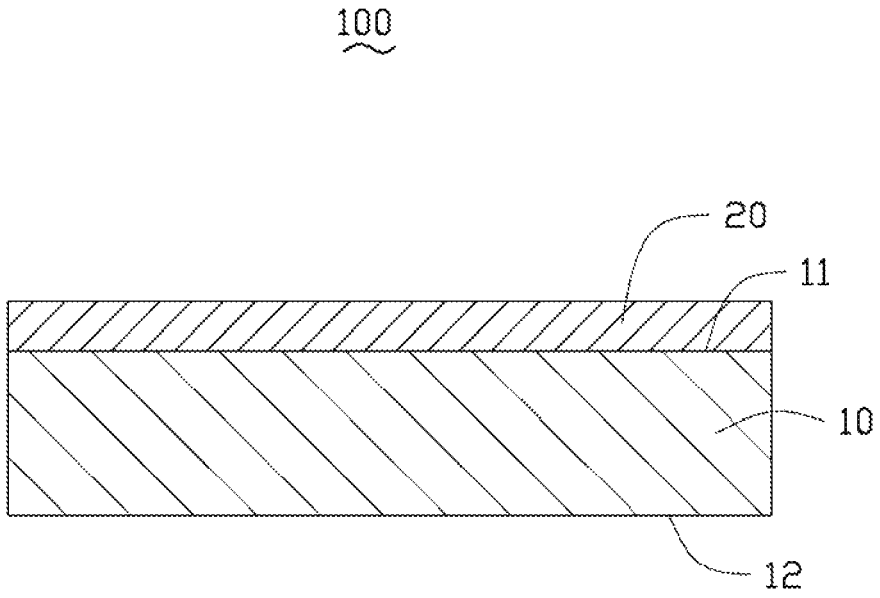


FIG. 1

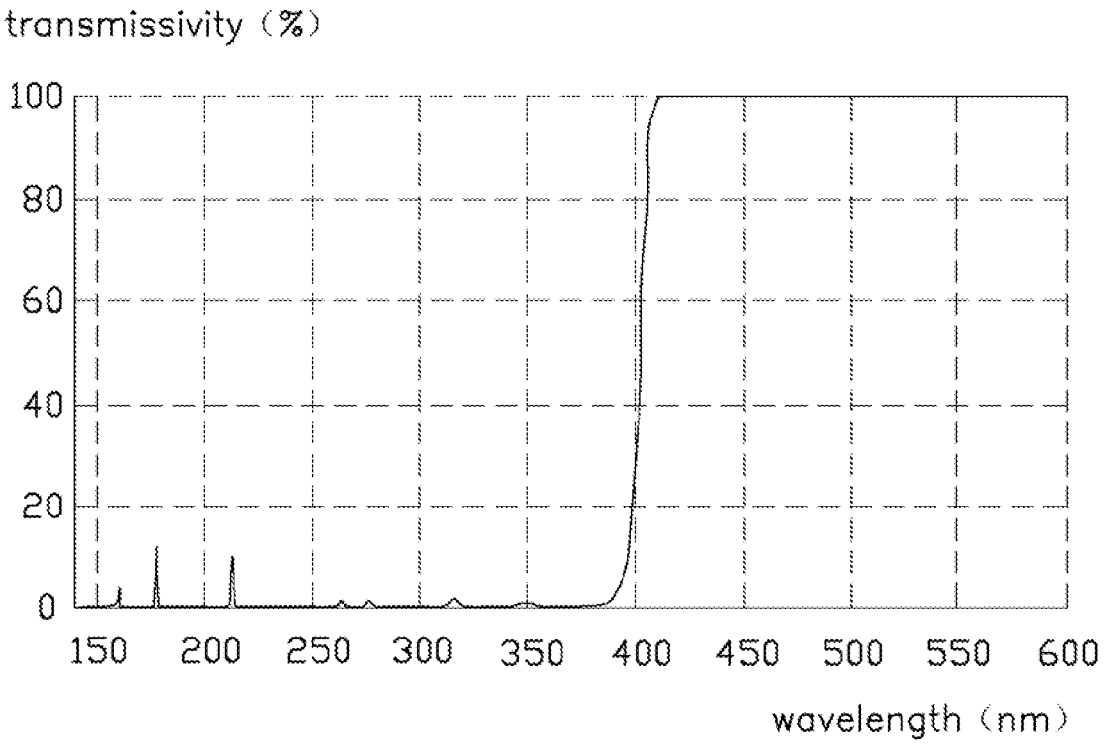

transmissivity (%)
100
80
60
40
20
0
150
200
250
300
350
400
450
500
550
600
wavelength (nm)

FIG. 2

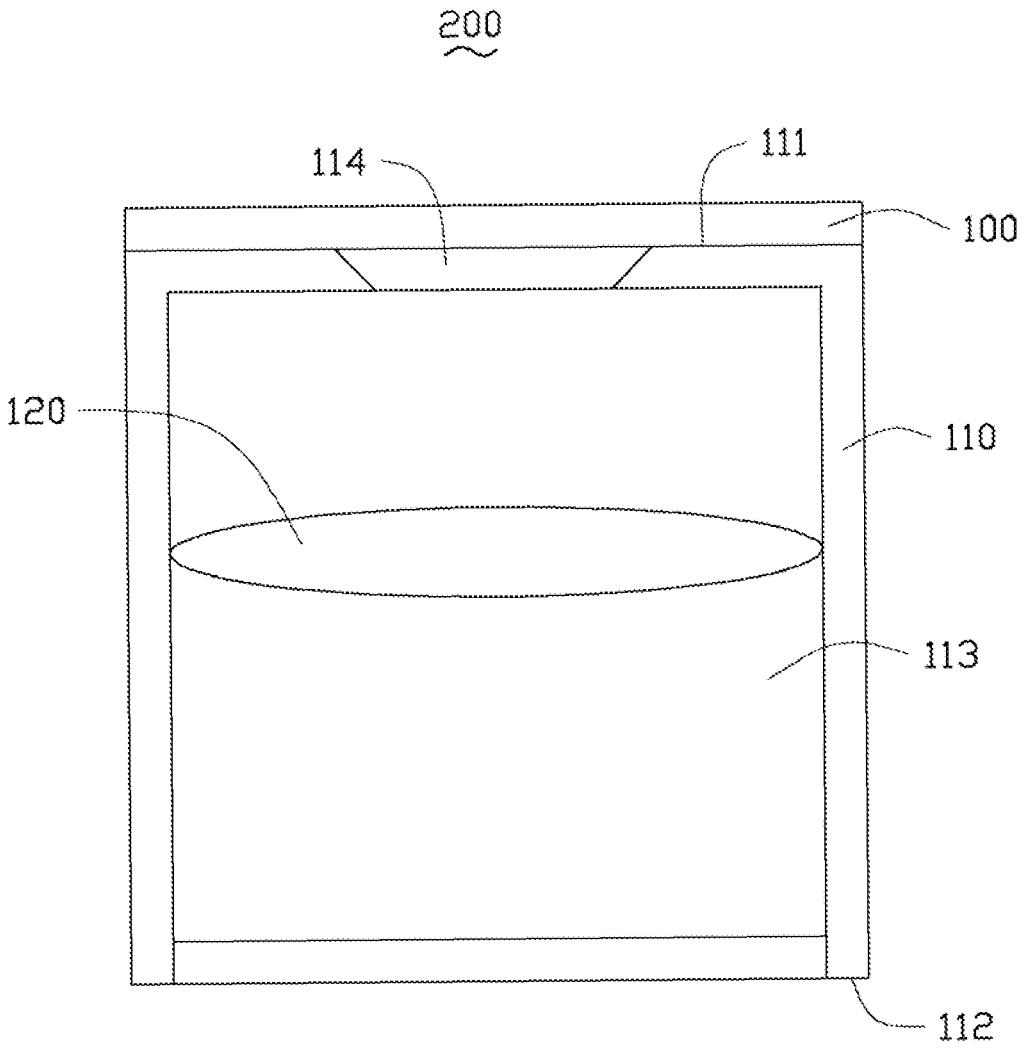


FIG. 3

OPTICAL ELEMENT FILTERING ULTRAVIOLET LIGHT AND LENS MODULE INCLUDING SAME

BACKGROUND

1. Technical Field

The present disclosure relates to optical elements, and particularly, to an optical element for filtering ultraviolet light and a lens module including the optical element.

2. Description of Related Art

Sapphires have excellent hardness and wear-resistance, and are used in optics and machinery. The sapphire can be used as a cover glass to protect lenses received in a lens module. However, quality of images captured by the lens module may be affected by ultraviolet light as the sapphire transmits ultraviolet light.

Therefore, it is desirable to provide an optical element and a lens module, which can overcome the limitations described.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional schematic view of an optical element in accordance with an exemplary embodiment.

FIG. **2** is a graph showing a spectrum characteristic curve of the optical element of FIG. **1**.

FIG. **3** is a cross-sectional schematic view of a lens module using the optical element of FIG. **1**.

DETAILED DESCRIPTION

Embodiments of the disclosure will be described with reference to the drawings.

Referring to FIG. **1**, an optical element **100**, according to an exemplary embodiment, is configured to filter out (i.e., reject) ultraviolet light and transmit (i.e., pass) visible light. The optical element **100** includes a substrate **10** and a film **20** formed on the substrate **10**.

The substrate **10** is plated shaped and is made of sapphire. Sapphire is a gemstone variety of the mineral corundum, and has a hexagonal crystal structure. The main chemical component of sapphire is aluminum oxide, and the refractive index of the sapphire is from about 1.762 to about 1.770. A reflectivity of the substrate **10** at ultraviolet wavelengths from about 190 nm to about 400 nm is lower than 10%. A transmissivity of the substrate **10** at ultraviolet wavelengths from about 190 nm to about 400 nm is greater than 70%. The substrate **10** includes a first surface **11** and a second surface **12** opposite to the first surface **11**.

The film **20** is configured to increase the reflectivity of the substrate **10** at the ultraviolet lights, and is coated on the substrate **10** by a sputter method or an evaporation method. The film **20** includes a number of high refractive index layers and a number of low refractive index layers alternately stacked on the substrate **10**. A material of the high refractive index layers can be a titanium dioxide (TiO_2), and the refractive index of TiO_2 is from about 2.55 to about 2.76. A material of the low refractive index layers can be a magnesium fluoride (MgF_2), and the refractive index of MgF_2 is about 1.38.

The film **20** is stacked by a first layer to a forty-fourth layer in an order facing away from the first surface **11**. The high refractive index layer is the odd number layer, and the low refractive index layers are the even number layer. The thicknesses all the layers are about 14 nm, 38 nm, 17 nm, 16 nm, 20 nm, 41 nm, 21 nm, 37 nm, 17 nm, 39 nm, 25 nm, 45 nm, 19 nm, 35 nm, 19 nm, 34 nm, 10 nm, 20 nm, 19 nm, 31 nm, 15 nm, 32 nm, 35 nm, 42 nm, 28 nm, 43 nm, 15 nm, 28 nm, 35 nm, 44 nm, 27 nm, 74 nm, 29 nm, 57 nm, 26 nm, 69 nm, 36 nm, 35 nm, 43 nm, 39 nm, 39 nm, 30 nm, 22 nm, 84 nm, respectively. The error of the thickness of each layer is ±3 nm.

In the embodiment, the film 20 is coated on the first surface **11** of the substrate **10**. The material and thickness of each layer of the film **20** are shown in Table 1.

TABLE 1

Layers	Material	Thickness (nm)
First layer	TiO_2	14.38
Second layer	MgF_2	38.23
Third layer	TiO_2	17.90
Fourth layer	MgF_2	16.95
Fifth layer	TiO_2	20.42
Sixth layer	MgF_2	41.50
Seventh layer	TiO_2	21.57
Eighth layer	MgF_2	37.05
Ninth layer	TiO_2	17.21
Tenth layer	MgF_2	39.16
Eleventh layer	TiO_2	25.80
Twelfth layer	MgF_2	45.09
Thirteenth layer	TiO_2	19.88
Fourteenth layer	MgF_2	35.69
Fifteenth layer	TiO_2	19.08
Sixteenth layer	MgF_2	34.74
Seventeenth layer	TiO_2	10.52
Eighteenth layer	MgF_2	20.29
Nineteenth layer	TiO_2	16.96
Twentieth layer	MgF_2	31.03
Twenty first layer	TiO_2	15.81
Twenty second layer	MgF_2	32.09
Twenty third layer	TiO_2	35.00
Twenty fourth layer	MgF_2	42.54
Twenty fifth layer	TiO_2	28.04
Twenty sixth layer	MgF_2	43.07
Twenty seventh layer	TiO_2	15.48
Twenty eighth layer	MgF_2	28.10
Twenty ninth layer	TiO_2	35.74
Thirtieth layer	MgF_2	44.35
Thirty first layer	TiO_2	27.38
Thirty second layer	MgF_2	74.79
Thirty third layer	TiO_2	29.85
Thirty fourth layer	MgF_2	57.39
Thirty fifth layer	TiO_2	26.90
Thirty sixth layer	MgF_2	69.57
Thirty seventh layer	TiO_2	36.05
Thirty eighth layer	MgF_2	35.53
Thirty ninth layer	TiO_2	43.30
Fortieth layer	MgF_2	39.50
Forty first layer	TiO_2	39.31
Forty second layer	MgF_2	30.48
Forty third layer	TiO_2	22.99
Forty fourth layer	MgF_2	84.91

The high refractive index layer and the low refractive index layer can be other materials. The number of layers and the thickness of each layer can be designed according to actual requirement.

Referring to FIG. **2**, a graph showing a spectrum of the optical element **100** is illustrated. The reflectivity of the optical element **100** at the ultraviolet wavelengths from about 190 nm to about 400 nm is about 100%. The transmissivity of the substrate **10** at the visible wavelengths greater than 400 nm is about 100%.

Referring to FIG. **3**, a lens module **200**, according to an exemplary embodiment, includes the optical element **100**, a lens barrel **110**, and at least one lens **120**. The lens barrel **110** includes an object side **111** and an image side **112** opposite to the object side **111**. A receiving room **113** is formed between the object side and the image side **112**. The lens barrel **110** defines a light entering hole **114** communicating with the receiving room **113** and positioned on the object side **111**. The at least one lens **120** is received in the receiving room **113**. The object side **111** is covered by the optical element **100**, and

the light entering hole **114** is sealed by the optical element **100**. The optical element **100** not only can filter ultraviolet light and transmit visible light, but also can protect the lens module **200** from being damaged by an external force.

Particular embodiments are shown and described by way of illustration only. The principles and the features of the present disclosure may be employed in various and numerous embodiments thereof without departing from the scope of the disclosure as claimed. The above-described embodiments illustrate the scope of the disclosure but do not restrict the scope of the disclosure.

What is claimed is:

1. An optical element, comprising:

a substrate made of sapphire; and

a film covered on the substrate and configured for increasing reflectivity of ultraviolet lights and filtering the ultraviolet lights; the film comprising a plurality of high refractive index layers and a plurality of low refractive index layers alternately stacked on the substrate, wherein the film is stacked by a first layer to a forty fourth layer in an order facing away from the substrate, the high refractive index layers are the odd number layers, the low refractive index layers are the even number layers, thicknesses of the first through forty fourth layers are about 14 nm, 38 nm, 17 nm, 16 nm, 20 nm, 41 nm, 21 nm, 37 nm, 17 nm, 39 nm, 25 nm, 45 nm, 19 nm, 35 nm, 19 nm, 34 nm, 10 nm, 20 nm, 19 nm, 31 nm, 15 nm, 32 nm, 35 nm, 42 nm, 28 nm, 43 nm, 15 nm, 28 nm, 35 nm, 44 nm, 27 nm, 74 nm, 29 nm, 57 nm, 26 nm, 69 nm, 36 nm, 35 nm, 43 nm, 39 nm, 39 nm, 30 nm, 22 nm, 84 nm, respectively, and the error of the thickness of each layer is ±3 nm.

2. The optical element of claim **1**, wherein a material of the high refractive index layers is titanium dioxide (TiO_2), and a material of the low refractive index layers is magnesium fluoride (MgF_2).

3. A lens module, comprising:

a lens barrel comprising an object side and an image side opposite to the object side, the lens barrel defining a receiving room between the object side and the image side, the lens barrel defining a light entering hole communicating with the receiving room and positioned on the object side;

at least one lens received in the receiving room; and

an optical element covering the light entering hole, the optical element comprising:

a substrate made of sapphire; and

a film covered on the substrate and configured for increasing reflectivity of ultraviolet lights and filtering the ultraviolet lights; the film comprising a plurality of high refractive index layers and a plurality of low refractive index layers alternately stacked on the substrate, wherein the film is stacked by a first layer to a forty fourth layer in an order facing away from the substrate, the high refractive index layers are the odd number layers, the low refractive index layers are the even number layers, thicknesses of the first through forty fourth layers are about 14 nm, 38 nm, 17 nm, 16 nm, 20 nm, 41 nm, 21 nm, 37 nm, 17 nm, 39 nm, 25 nm, 45 nm, 19 nm, 35 nm, 19 nm, 34 nm, 10 nm, 20 nm, 19 nm, 31 nm, 15 nm, 32 nm, 35 nm, 42 nm, 28 nm, 43 nm, 15 nm, 28 nm, 35 nm, 44 nm, 27 nm, 74 nm, 29 nm, 57 nm, 26 nm, 69 nm, 36 nm, 35 nm, 43 nm, 39 nm, 39 nm, 30 nm, 22 nm, 84 nm, respectively, and the error of the thickness of each layer is ±3 nm.

4. The lens module of claim **3**, wherein a material of the high refractive index layers is titanium dioxide (TiO_2), and a material of the low refractive index layers is magnesium fluoride (MgF_2).

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